

Soil Survey Technical Note No. 5

Assessing carbonates in the field with a dilute hydrochloric acid (HCl) solution

Purpose

This technical note affirms one molar¹ hydrochloric acid (1 M HCl) as the standard solution for determining *effervescence class* and thus resolves conflicting statements in the "Soil Survey Manual" about the use of HCl concentration for determining effervescence class in the field (Soil Survey Staff, 1993, pg. 192). The note also provides instructions for preparing HCl solutions and guidance for detecting carbonates in the field.

Standard

The standard for determining *effervescence class* in the field is 1 M HCl at ambient temperature. Results from other acid concentrations are not directly comparable. Acid concentrations other than 1 M HCl should be specified in the pedon description.

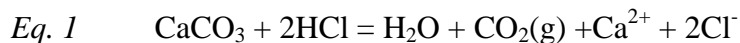
It is important to differentiate the determination of *effervescence class* from other field activities in which dilute HCl is used. The 1 M HCl standard applies only to *effervescence class determinations*. Concentrations other than 1 M HCl may be used to detect the *presence* of carbonates in other field activities (e.g., 3 M or 6 M HCl to assess dolomite occurrence).

Carbonates in soil

Various primary and secondary carbonates are found in soils (Doner and Lynn, 1989). The most common types are calcite (CaCO_3) or a poorly crystalline equivalent and dolomite [$\text{CaMg}(\text{CO}_3)_2$]. Less common soil carbonates include sodium carbonate (Na_2CO_3) and siderite (FeCO_3). Carbonates buffer soil pH and are an indication of the relative abundance of bases. The presence of Ca^{+2} promotes clay flocculation. Besides these pedogenic implications, carbonate minerals play an important role in soil management (Doner and Lynn, 1989). The distribution and amount of carbonates influence soil fertility, erodibility, and available water capacity.

¹ Molarity (M) is the unit for reporting chemical concentrations in the SI system. The relationship between normality (N) and molarity (M) is expressed by $N=nM$, where n is the number of replaceable H^+ or OH^- per molecule. In the case of HCl, molarity and normality are identical (one replaceable H^+ per molecule).

Carbonates effervesce when treated with dilute hydrochloric acid (*Eq. 1*). The extent and rate of effervescence are affected by the amount of carbonates, the chemical and physical nature of the carbonates (e.g., particle size and mineralogy), the temperature and water content of the soil, and the temperature and concentration of the HCl applied to the sample. Consequently, effervescence is not a precise indicator but a relative index of the amount of carbonates in the soil matrix.



Field carbonate detection and effervescence class assessment

A dilute HCl solution is used in two ways to assess carbonates in the field: 1) a quick test to detect carbonate presence, and 2) a qualitative test for assigning effervescence class to the soil matrix, primarily used in describing soil profiles. For a semiquantitative measurement of carbonates in the field, use the calcimeter method (also called manometric carbonate method; Nelson, 1982).

1) Detecting the presence of carbonates: A drop of dilute HCl applied to a soil sample is widely used as a quick test to confirm the presence of carbonate. No single standard HCl concentration is specified for detecting carbonates. Although 1 M HCl is the norm, 3 M HCl is traditionally used in some regions of the country. Each concentration serves well under certain soil and mineralogical conditions.

The presence/absence test is used in soil survey for three overlapping but operationally separate purposes.

1. Bedrock and bedrock fragment identification.—Is the bedrock or fragment limestone, dolomite, or noncarbonatic? The specimen can be scratched, broken, or powdered (by a rock hammer) to expose fresh material or increase surface area. Acid concentrations greater than 1 M can be used to distinguish between dolomite and limestone. The degree and rate of reaction are the key characteristics. Dolomite reacts slowly and to a lesser degree than limestone. Dolomitic carbonates may be more easily recognized with acid concentrations greater than 1 M.
2. Soil concentration identification.—Carbonate concentrations (nodules, concretions, threads, and masses) are identified by a positive reaction. Failure of a carbonate concentration to react is most likely the result of a weathering rind or coating of different, nonreactive material. Dolomite rarely forms as a secondary or authigenic mineral in soil. It is best to break hard concentrations and apply acid to a fresh surface or to crush the specimen to increase the surface area.
3. Carbonates in the soil matrix.—Acid is applied directly to the soil specimen. A positive reaction confirms the presence of carbonates. The carbonates may be primary, secondary, or both. Carbonates including dolomite in soil can be inherited from parent material and occur in the fraction <2 mm in size. The specimen can be placed in a spot plate and given time (1 to 2 minutes) to react. Dolomitic carbonates react slowly; the reaction can be easily overlooked. Carbonates may occur in specific locations (e.g., along faces of peds). A number of specimens and locations should be tested. Dolomitic carbonates or specimens with a low content of carbonates may be more easily recognized with acid concentrations greater than 1 M.

These quick test results do not substitute for the *effervescence class* assessment, in which the reaction of the entire soil matrix is assessed.

- 2) **Effervescence class assessment:** The preferred method is to place a sufficient amount of soil matrix material into a spot-plate depression, add 1 to 2 drops of 1 M HCl, observe the initial reaction, and wait about 2 minutes before assessing the final extent of effervescence and assigning the appropriate effervescence class. Table 1 can be used to assign the effervescence class.

Table 1.—Effervescence classes used to describe the entire soil matrix using 1 M HCl.

Effervescence class	Criteria
Noneffervescent:	No bubbles detected.
Very slightly effervescent:	Few bubbles seen.
Slightly effervescent:	Bubbles readily seen.
Strongly effervescent:	Bubbles form low foam.
Violently effervescent:	Thick foam forms quickly.

Preparing dilute HCl concentrations

(Read the Safety section below before preparing dilutions.)

Muriatic acid (also known as muratic acid), a common HCl stock solution found at most hardware and swimming pool supply stores, is diluted with water to prepare HCl field solutions. The dilution factor depends on the concentration of HCl stock solution. Currently available grades of muriatic acid contain about 32 percent HCl by weight. Specific concentrations are shown on the product label. Reagent grade HCl is also available from chemical suppliers and may have a slightly higher concentration.

Dilution using a graduated cylinder:

A concentration prepared with a graduated cylinder is the preferred method. Table 2 shows the amounts of HCl stock solutions of different concentrations required to prepare 1-liter of 1 M, 3 M, and 6 M HCl. A lesser volume of HCl field solution can be prepared by proportionally reducing the volume of HCl stock solution. For example, to prepare 250 ml of 1 M HCl from 30% muriatic acid, reduce the volume of HCl stock solution by 1000 mL/250 mL, a factor of 4: $106 \text{ mL}/4 = 27 \text{ mL}$ (30% HCl), adding enough distilled water to achieve the required volume of 250 mL.

Table 1.—Volume of HCl stock solution required to prepare 1 liter of 1 M, 3 M, and 6 M HCl.

HCl stock solution	Volume of HCl stock solution required, (mL)
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concentration, wt %	1 M	3 M	6 M
28	114	343	686
30	106	317	635
32	98	295	590
34	92	275	550
36	86	258	516
38	81	242	485

Dilution formulas using any container:

In the absence of a calibrated cylinder, the following mixtures of any of the HCl stock solutions in table 1 with distilled water will provide concentrations suitable for qualitative field use:

1 M HCl approximation.—Combine 1 volume of HCl stock solution with 9 volumes distilled H₂O. The resultant concentration ranges from about 0.9 to 1.2 M HCl.

3 M HCl approximation.—Combine 3 volumes of HCl stock solution with 7 volumes distilled H₂O. The resultant concentration ranges from about 2.6 to 3.7 M HCl.

6 M HCl approximation.—Combine 3 volumes of HCl stock solution with 2 volumes distilled H₂O. The resultant concentration ranges from about 5.2 to 7.4 M HCl.

Safety

Hydrochloric acid is corrosive. When working with concentrated acids, always wear protective gloves and eyewear.

Caution: Always add the concentrated acid to the water in the dilution container. If water is added to concentrated acid (not recommended), the heat of dilution can cause the mixture to boil and spatter. Post the *Material Safety Data Sheet*² provided by the supplier near the HCl storage area. Refer to the *Material Safety Data Sheet* for additional handling and storage precautions. If a *Material Safety Data Sheet* is not provided when the acid is purchased, then request one from the supplier.

Label all containers with the following:

DANGER: Hazardous Chemical

² A Material Safety Data Sheet (MSDS) is a document that contains information on the potential health effects of exposure and how to work safely with the chemical product. It is an essential starting point for the development of a complete health and safety program. It contains hazard evaluations on the use, storage, handling, and emergency procedures related to that material. The MSDS contains much more information about the material than the label and is prepared by the supplier. It is intended to tell what the hazards of the product are, how to use the product safely, what to expect if the recommendations are not followed, what to do if accidents occur, how to recognize symptoms of overexposure, and what to do if such incidents occur.

M Hydrochloric Acid (e.g., 1 M Hydrochloric Acid)
DATE:

A 1 M HCl solution can cause mild skin irritation and damage clothing. Greater caution is warranted when higher HCl concentrations (3 and 6 M) are handled, as they can cause more serious skin and eye irritation than 1 M. Hydrochloric acid can be neutralized by immediately applying sodium bicarbonate (baking soda) or other safe bases. All acids should be handled and stored with appropriate care to avoid damage to skin or clothing. All acids should be stored in safe, re-sealable, nonbreakable receptacles (e.g., a polypropylene squeeze bottle) and properly labeled (date prepared, acid type and strength).

Contact

The contact for this technical note is the National Leader for Soil Classification and Standards, National Soil Survey Center, Lincoln, NE.

References

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